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New scaling variable at ISR energies for p+p→π^++x inclusive reactions

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The inclusive cross section for $p+p \to \pi^+ + X$ reactions at ISR energies can be represented by a single scaling variable of the form $\eta = 2p_T{}^2x/\ln(s/s_0)$ for low p_T. It is found that at large p_T and not too small x the experimental data can also be represented by the same variable.

1. INTRODUCTION

The general properties of inclusive reactions, such as scaling, the exponential cut-off in the transverse momentum p_T, the dependence of multiplicity with energy is of interest to many physicists in the field of high energy particle physics.

The machine experiments of CERN Group (Capiluppi *et al* 1974) provide inclusive spectrum of charged particles at ISR energy range $\sqrt{s} = 23.3-53$ GeV. They gave data at moderate spectral region of p_T, viz., in the range 0.2–1.2 GeV/c. Moreover, Cottrell *et al* (1975) provide the data at $\sqrt{s} = 52.5$ GeV for p_T interval 1.3–4.7 GeV/c. They suggest that the Lorentz invariant cross section at fixed angle can be approximated by

$$E\frac{d^3\sigma}{d^3p} = K\exp(-Bp_T)$$

and the slope of the distribution decreases monotonically with increasing angle from $B = 4.9 \pm 0.1$ for $\theta = 10.2^\circ$ to $B = 3.4 \pm 0.1$ for $\theta = 20.8^\circ$.

In the present investigation we shall study the scaling properties of the Intersecting Storage Ring data for inclusive reaction $p+p \to \pi^+ + X$ in a wide range of value of p_T and x by using a single scaling variable.

2. RESULTS AND DISCUSSION

Figures 1 and 2 show the Lorentz invariant cross section data plotted against $\eta = 2p_T{}^2x/\ln(s/s_0)$, where $s_0 = 1$ GeV and x is the usual Feyman variable (Capiluppi *et al* 1974 and Cottrell *et al* 1975) in the center of mass energy range of proton $\sqrt{s} = 23$–53 and 52.5 GeV, respectively. It is found that the inclusive cross section for $p+p \to \pi^+ + X$ reactions for $0.075 \leqslant x \leqslant 0.3$ and $0.2 \leqslant p_T \leqslant 1.5$

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GeV/c, the ISR data of Capiluppi *et al* (1974) follow the relation (solid curve in figure 1)

$$E\left(\frac{d^3\sigma}{d^3p}\right)\ln(s/s_0) = A\exp(-a\eta + b\eta^2) \quad \ldots (1)$$

where $A = 168\,7$ (mb/GeV^2/c^3), $a = 113.9$ and $b = 683\,4$ in the interval $0\,003 \leqslant \eta \leqslant 0.1$.

The recent data of Cottrell *et al* (1975) at center of mass energy range) $\sqrt{s} = 52\,5$ GeV follow a power law of the following form

$$E\frac{d^3\sigma}{d^3p} \sim 10^{-4}\,\eta^{-4\cdot 83}$$

in the region $1\,9 \leqslant p_T \leqslant 4\,7$ GeV/c and $x = 0.25$ -0 50 for $0\,3 \leqslant \eta \leqslant 0\,3$

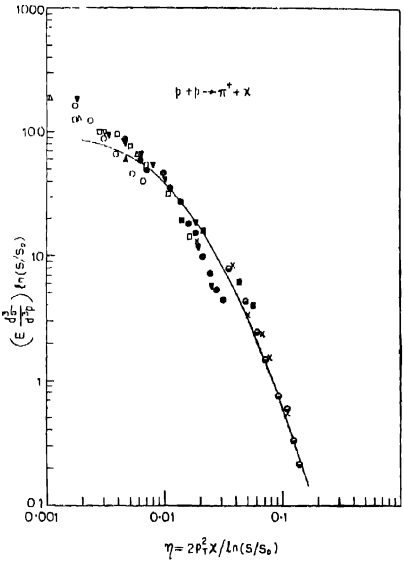

Fig. 1. The cross section data for $p+p \to \pi^+ + x$ reactions,

$$\ln(s/s_0)E\frac{d^3\sigma}{d^3p} \text{ vs } \eta = 2p_T{}^2c/\ln(s/s_0)$$

have been plotted from the work of Capiluppi *et al* (1974). Solid line shows the fit from eq (1). Experimental data :

$\sqrt{s} = 23.3$ GeV	Δ for $x = 0.15$,	▲ for $x = 0.3$;	
$\sqrt{s} = 30.6$ GeV	□ for $x = 0.15$,	■ for $x = 0\,3$;	
$\sqrt{s} = 44\,6$ GeV	▽ for $x = 0.075$,	▼ for $x = 0\,15$,	⋎ $= 0\,3$;
$\sqrt{s} = 53.0$ GeV	O for $x = 0.075$,	● for $x = 0.15$,	⊙ $x = 0.3$.

Figures 1 and 2 show that the experimental cross section data at different incident energies follow the universal curves and satisfy the scaling behaviour at different energies. Such scaling property of the data is evident for small p_T also which suggests an exponential nature and at higher momentum the power law behaviour is predominant.

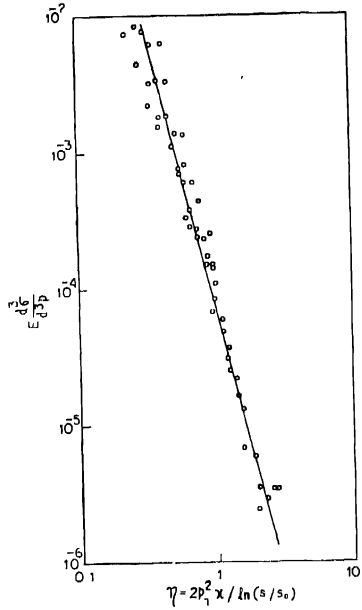

Fig. 2. The cross section data for $p+p \to \pi^+ + x$ reactions. $E\dfrac{d^3\sigma}{d^3p}$ plotted as a functions of $\eta = 2p_T^2 x/\ln(s/s_0)$ at center of mass energy $\sqrt{s} = 53$ GeV.
Data : O – Cottrell *et al* (1975) for $x = 0.25 - 0.50$.

3. Conclusion

The present formalism suggests that the single parameter $\eta = 2p_T^2 x/\ln(s/s_0)$ can explain the scaling properties of the Intersecting Storage Ring data for inclusive reaction $p+p \to \pi^+ + X$ in a surprisingly wide range of value of p_T and x.

References

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